

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EOP4066 – OPTICAL COMMUNICATION SYSTEMS

(All sections/Groups)

15 OCTOBER 2018
2:30 p.m. – 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

- (a) Table 1 lists the characteristics of Fibers A, B and C. These fibers are commonly used in optical communication systems.

Table 1: Characteristics of Fibers A, B and C

Fiber type	Numerical aperture (NA)	Core diameter (μm)	Refractive index profile parameter (α)
A	0.14	8.2	-
B	0.20	50.0	-
C	0.20	62.5	2

- (i) Name the three types of fibers (Fibers A, B and C) listed in Table 1. [3 marks]
- (ii) Which type of fiber is suitable to be used in a local area network (LAN)? Justify your answer. [3 marks]
- (iii) Estimate the number of guided modes in Fiber C if the operating wavelength is 1550 nm. [4 marks]
- (iv) Propose an optical source that can couple efficiently into Fiber A. Justify your answer. [3 marks]
- (v) Propose an optical source that can couple efficiently into Fiber B. Justify your answer. [3 marks]
- (vi) With the help of suitable diagrams, propose THREE (3) network topologies that can be used in an optical fiber network with 5 stations. Your diagram should be clearly labelled to show the stations, optical fiber trunk lines and relevant optical components. [9 marks]

Continued

Question 2 (25 marks)

- (a) Attenuation and dispersion affect the system performance of an optical communication system. Table 2 lists the attenuation loss and dispersion value for a commercially available fiber, Corning SMF-28, which has a core diameter of 8.2 μm .

Table 2: Attenuation loss and dispersion value for Corning SMF-28.

Corning SMF-28	
Attenuation at 1310 nm (dB/km)	0.32
Attenuation at 1550 nm (dB/km)	0.18
Dispersion value at 1550 nm (ps/(nm.km))	18.00

- (i) Describe TWO (2) loss mechanisms related to the material composition and fabrication process for the fiber that are responsible for signal attenuation in optical fibers. [4 marks]
- (ii) Suggest TWO (2) ways to minimize the effects of the loss mechanisms described in your answer in Question 2 (a)(i). [4 marks]
- (iii) If 50 km of Corning SMF-28 fiber is used in a point-to-point optical transmission link, what is the signal attenuation at 1310 nm and 1550 nm? Assume that no connectors or splices are used. Comment on your answer with ONE (1) reason to justify the result. [6 marks]
- (iv) What causes chromatic dispersion in optical fibers? [2 marks]
- (v) Describe how dispersion limits the transmission capacity of an optical fiber in an optical communication system. [4 marks]
- (vi) The Corning SMF-28 fiber described in Table 2 is connected to a laser source with a wavelength of 1550 nm and a source bandwidth of 1.2 GHz. Calculate the threshold power for both stimulated Brillouin scattering and stimulated Raman scattering. Comment on your answer. [Hint: Threshold power for SBS, $P_B = 4.4 \times 10^{-3} d^2 \lambda^2 \alpha_{dB}$ watt and threshold power for SRS, $P_R = 5.9 \times 10^{-2} d^2 \lambda \alpha_{dB}$ watt]. [5 marks]

Continued

Question 3 (25 marks)

(a) The following optical communication systems are operating at 100 Mb/s.

System A operating at 850 nm

1. Laser diode: 1 mW fiber-coupled power
2. Avalanche photodiode: -50 dBm sensitivity
3. Fiber: 3.5 dB/km attenuation at 850 nm
4. Connector loss: 1 dB/connector

System B operating at 1300 nm

1. LED: -13 dBm fiber-coupled power
2. PIN photodiode: -38 dBm sensitivity
3. Fiber: 1.5 dB/km attenuation at 1300 nm
4. Connector loss: 1 dB/connector

- (i) Describe TWO (2) differences between the optical sources used in System A and System B. [4 marks]
- (ii) Describe the TWO (2) photodetectors used in System A and System B in terms of structure and operating principle. [4 marks]
- (iii) Assuming a 6 dB system margin, determine the maximum possible transmission distance for both System A and System B. You may make assumptions on the number of connectors to be used. [10 marks]
- (iv) If the optical sources and photodetectors in System A and System B can be operated at both 850 nm and 1300 nm, propose an optical source, photodetector and fiber (from either System A or System B) that can give the highest transmission distance. Justify your answer with relevant calculations and compare your final answer with your answer in Q3 (a)(iii). Assume a 6 dB system margin and use the same number of connectors as your answer in Q3 (a)(iii). [7 marks]

Continued

Question 4 (25 marks)

- (a) As a network engineer, you have been assigned to upgrade the transmission capacity of an existing fiber network link between two cities.
- (i) Wavelength division multiplexing (WDM) has been proposed as a suitable multiplexing scheme for the network upgrade. Describe WDM and its optical channel in detail. [6 marks]
 - (ii) Describe TWO (2) technical challenges in using wavelength sensitive devices. [4 marks]
 - (iii) To build a WDM system, the band of wavelengths allocated for each channel is significantly wider than the signal. Describe TWO (2) reasons for this. [4 marks]
 - (iv) Propose a suitable multiplexer and demultiplexer for the WDM system. Justify your answer. [4 marks]
 - (v) NRZ and RZ digital modulation scheme can be used in the proposed fiber network link. Describe these two modulation scheme with suitable examples. [4 marks]
 - (vi) Based on your answer in Q4 (a)(v), which type of digital modulation scheme is suitable for a higher bit rate network link? Justify your answer. [3 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^8 m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ϵ_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A ²
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

End of Paper

